Into the Future with Green Roofs

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Abstract

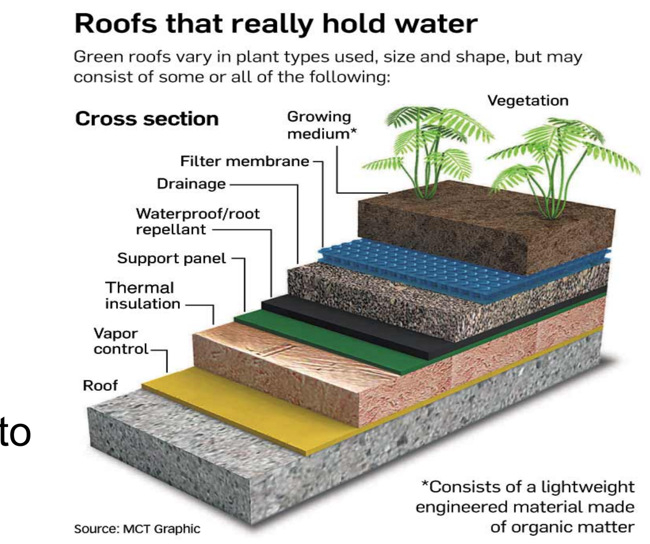
New York City experiences a phenomenon called the Urban Heat Island Effect. This effect causes urban regions, with their closely spaced buildings and extensive paved surfaces, to become as much as 9-27˚F warmer than rural areas. As a result, urban communities experience increases in energy demand, air pollution, greenhouse gas emissions, heat-related and air quality illnesses, and a decrease in water quality. These issues are expected to become more severe with future climate change.

Green roofs help to mitigate the urban heat island effect. They also provide ecological benefits for animals and plants that have been displaced from their primary ecosystems. It is evident that green roofs have a positive impact on our "urban ecosystem," but the long-term efficiency of green infrastructure under conditions of future climate in the New York City area has not yet been explored. For this project, we will model various climate change scenarios for New York City over the coming decades, and assess whether green roofs in New York City will need to be adapted, either structurally or ecologically, for temperature and precipitation conditions that may be rather different (and perhaps far more severe) than present.

Introduction

A green roof is a roof partially or completely covered with a vegetation layer that contains plants, soil, and other growing media. Green roofs insulate buildings, protect the roof from temperature extremes, and reduce storm water run off. There are three types of green roof systems:

- Extensive roofs: used on residential buildings; shallow soil (≤ 6 inches) and small plants; simple installation and maintenance
- Intensive roofs: used mainly on commercial buildings; elaborate garden-like design, with larger plants and walkways; irrigation and drainage systems have to be well operated to reduce the chance of overloading the roof
- Hybrid green: contain elements of both intensive and extensive roof design



Green Roof Ecosystem

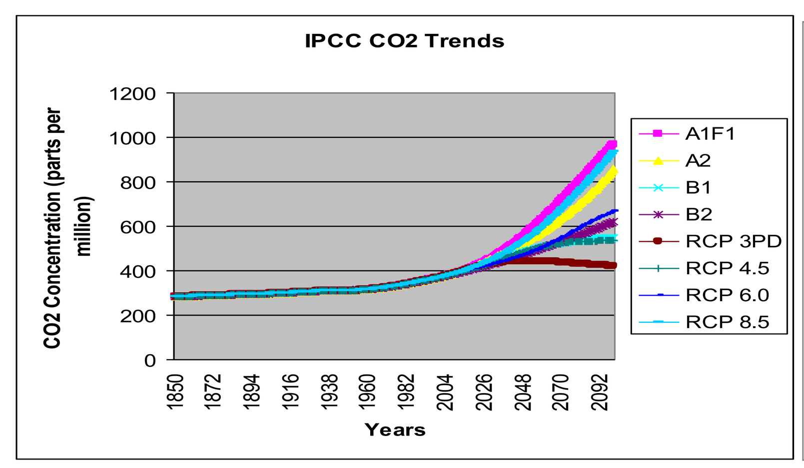
Green roofs serve as ecosystems in that they provide space for plants and animals to flourish. The floral components of a green roof differ depending the type of green roof. Intensive roofs have a deeper layer of growing medium than extensive roofs can, and so intensive roofs hold greater diversity in terms of flora, including woody and perennial plants. Extensive roofs, on the other hand, have a shallow layer of growing medium (6 inches or less in depth), which limits plant types to small plants such as sedum and herbaceous plants.

The faunal component of these small ecosystems are limited to arthropods (insects, spiders). Most of the creatures observed on green roofs have been lady bugs, spiders, beetles, ants, bugs, flies, and most importantly bees. Other fauna found include snails, worms, and other invertebrates.

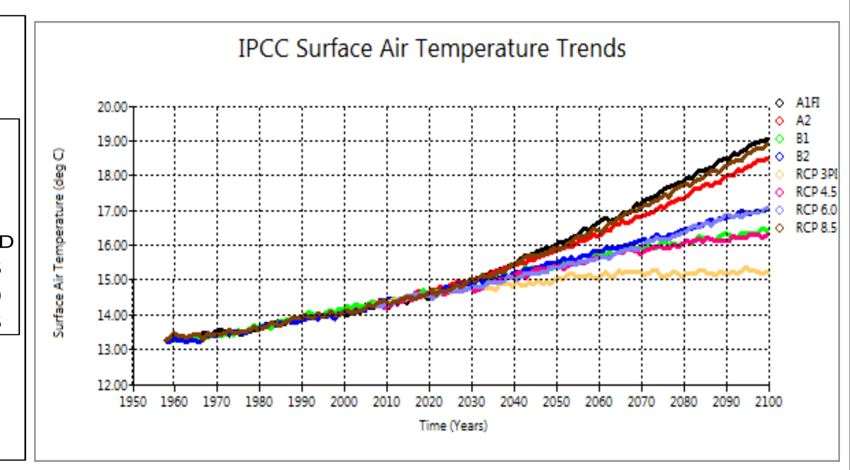
Some avian life has also been reported to be seen on the green roofs. This includes small nesting birds and birds on migratory paths that use these green roofs as resting stops on their journeys.

Assessing Potential Climate Change in NYC

To understand the range of potential future climate change in the New York City area, we have used EdGCM (the Educational Global Climate Model) to run a series of global simulations, each of which used greenhouse gas projections according to a variety of IPCC emissions scenarios.



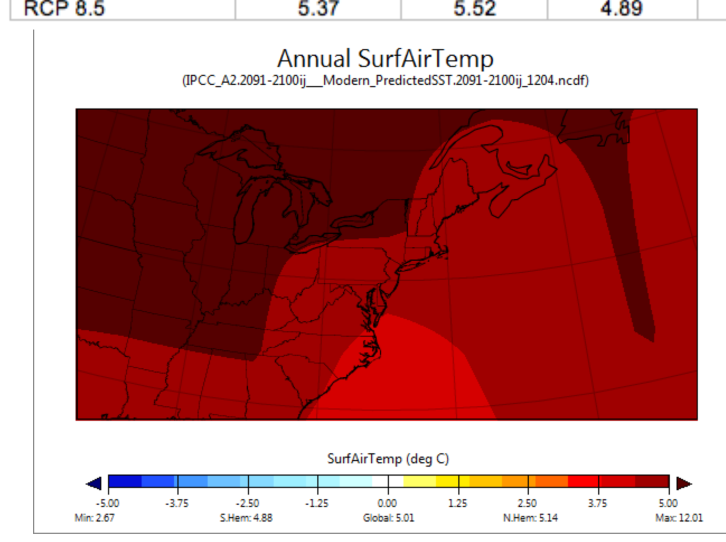
This plot projects the amount of C02 released for eight different IPCC scenarios, all of which are different in our response to future climate change.

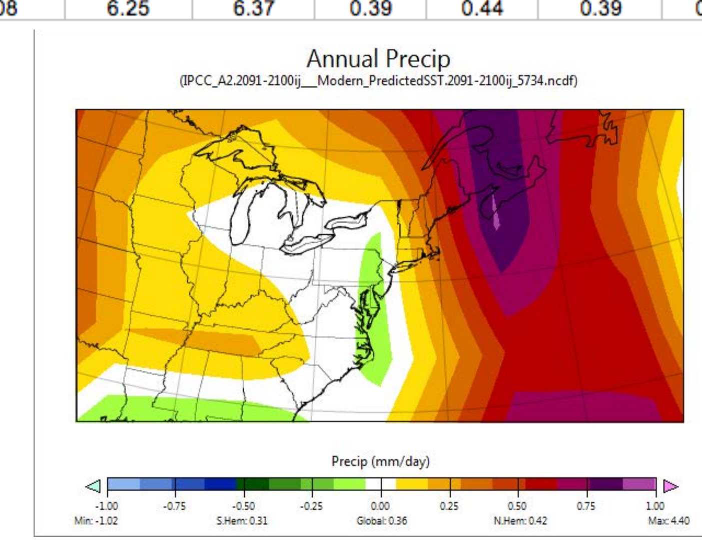


This plot projects the surface air temperature for eight different IPCC scenarios, all of which are different in our response to future climate change.

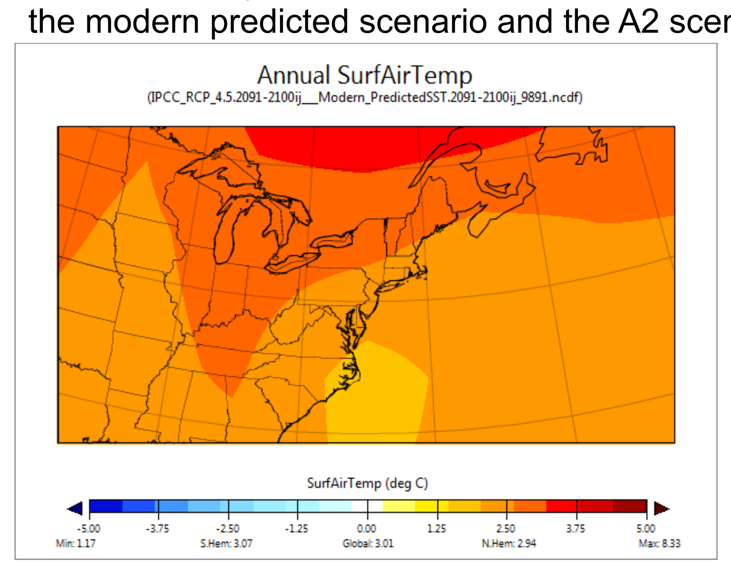
Table 1. Summary of key climate diagnostic variables from global climate simulations

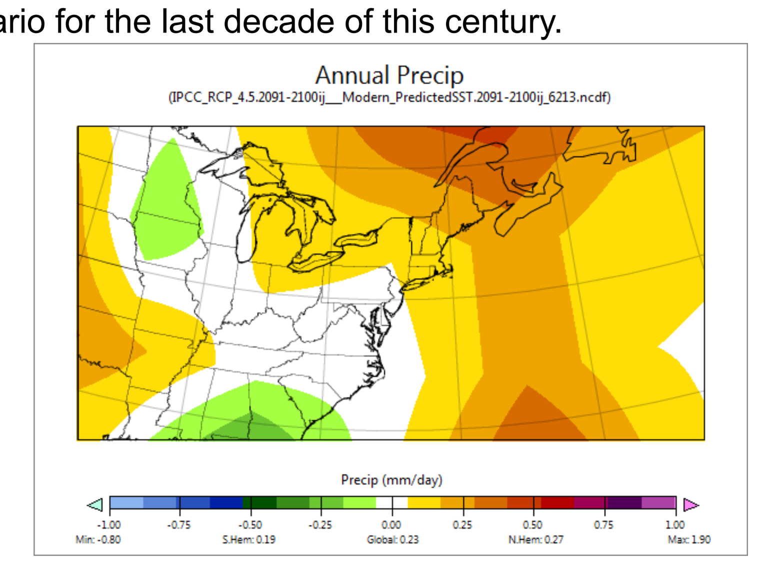
	Surface Air Temperature (deg C)		Max Surface Air Temperature (K)		Min Surface Air Temperature (K)		Precipitation (mm/day)		Evaporation (mm/day)	
Climate Scenario	Global	NH	Global	NH	Global	NH	Global	NH	Global	NH
A1FI	5.55	5.7	5.06	5.28	6.48	6.68	0.41	0.45	0.41	0.42
A2	5.01	5.14	4.56	4.73	5.84	5.92	0.36	0.42	0.36	0.37
B1	3.1	3.04	2.81	2.82	3.61	3.47	0.23	0.23	0.23	0.22
B2	3.69	3.7	3.36	3.43	4.3	4.22	0.27	0.3	0.27	0.27
RCP 3PD	2	1.92	1.8	1.77	2.32	2.16	0.16	0.15	0.16	0.15
RCP 4.5	3.01	2.94	2.72	2.73	3.51	3.37	0.23	0.27	0.23	0.22
RCP 6.0	3.68	3.74	3.33	3.43	4.3	4.3	0.27	0.32	0.27	0.27
RCP 8.5	5.37	5.52	4.89	5.08	6.25	6.37	0.39	0.44	0.39	0.41





These anomaly maps depict the difference in surface air temperature and precipitation from the modern predicted scenario and the A2 scenario for the last decade of this century.





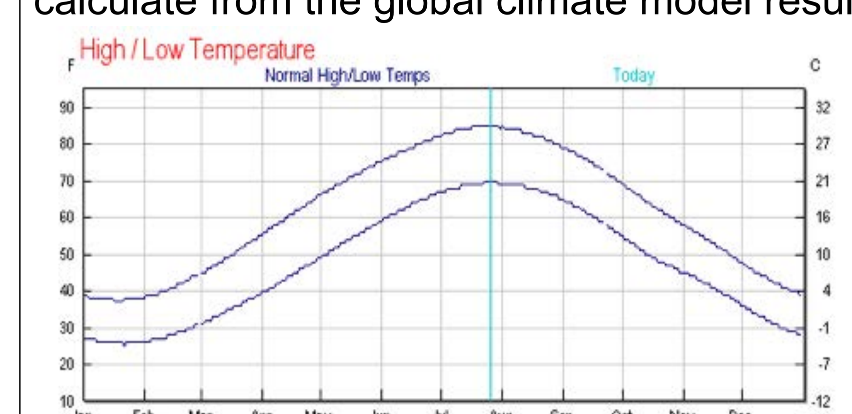
These anomaly maps depict the difference in surface air temperature and precipitation from the modern predicted scenario and the RCP 4.5 scenario for the last decade of this century.

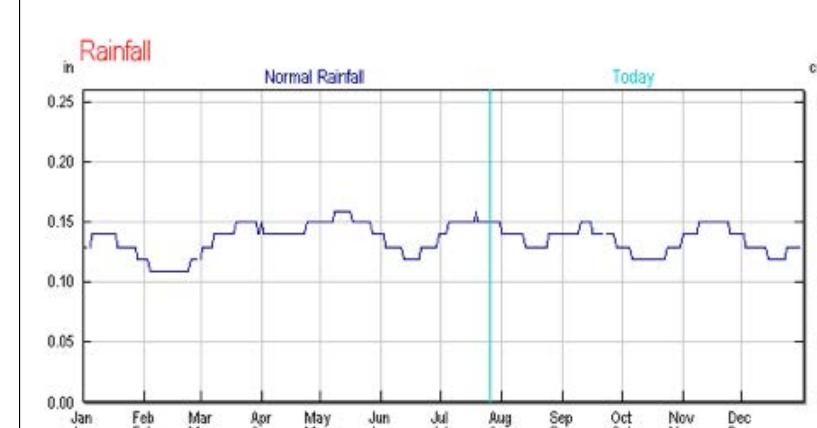
Analyses of Climate Simulations

For our analyses, we chose to focus on the model results of two IPCC emissions scenarios in particular: A2 (from the series of scenarios used in the IPCC's Third and Fourth Assessment reports), and RCP 4.5 (from the IPCC's Fifth Assessment, currently in progress. We selected these two as representative of two CO2 emissions futures that are possible: under the A2 scenario, CO2 emissions continue to increase without mitigation, whereas under RCP 4.5, CO2 emissions are eventually checked through mitigation activities (e.g., reduced dependence on fossil fuels).

The climate diagnostic variables most relevant for our analyses are average surface air temperature, minimum and maximum surface air temperatures, evaporation, and precipitation. Each of these variables is being explored in terms of annual and seasonal (DJF and JJA) averages, and as anomalies rather than absolute values (in order to help control for any bias present in the model).

In the next phases of our analyses, we will apply the anomalies we calculate from the global climate model results to climatological data from local New York City weather stations, in order to more directly evaluate the impacts of future change on structures This method climate data the delta





In the final phase of our investigation, we will explore the additional effects of extreme precipitation events.

At left, climatological norms for the Central Park weather station (courtesy Weather Underground).

Preliminary Results

Based on our surface air temperature graph, the A1FI scenario predicts the extreme case implementing no mitigation strategies. The RCP 3PD predicts the least severe case using sustainable technology showing the least increase in surface air temperature. In the CO2 graph we have noticed that the old IPCC scenarios have a higher CO2 trend then the RCP scenarios. We chose the A2 and RCP 4.5 scenarios because we believe these scenarios are most likely to happen in the New York City area. The A2 scenario will occur if no mitigation strategies are put in to affect while the RCP 4.5 scenario will occur if the city becomes greener. For the duration of our time left at GISS we will compare the data collected by NYC weather stations to our predicted data. This will be done to see if any changes need to be made to any part of the green roof in effort to adapt to climate change.

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